CEMENT AND LIME MANUFACTURE

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"Air-Entraining" Cement.

A DISCUSSION on the use of air-entraining agents, such as vinsol resin and tallow, in Portland cements was held at a recent convention of the American Concrete Institute. Mr. F. T. Sheets, the manager of the Portland Cement Association, said that these admixtures had given a new faith in concrete, while Mr. H. F. Gonnerman, the manager of the Association's research laboratory, stated that these admixtures increased the resistance of concrete to salts and that the decrease in the strength of the concrete resulting from the addition could be avoided by reducing the water and sand content of the concrete.

Mr. F. H. Jackson, Public Roads Administrator of Washington, said that there was sufficient knowledge now to prove these additions made concrete resistant to freezing and thawing. However, the amount of entrapped air must be controlled; much depended on the character of the cement used, the method of applying the air-entraining agent, etc. While he thought the loss in strength might be compensated for by increased durability, he did not believe that the indiscriminate use of air-entraining agents was a cure-all. Concrete with 3 to 5 per cent. air entrapment showed loss of strength of up to 25 per cent; the flexural strength, particularly, was lowered. Some of the strength could be recovered by redesigning the mix, in some cases without the addition of cement, but some mixes required as much as 680 lb. of cement to a cubic yard of concrete. He was sceptical of the advantage of using air-entraining cements in structural concrete. Evidently they would reduce the bond with reinforcement. He also questioned whether all the benefits derived from air-entraining cements were due to air entrapment; some might be due to the use of a waterproofing agent.

Mr. Henry L. Kennedy, of the Dewey and Almy Chemical Co., reported the results of experiments with a variety of air-entraining agents. It had been found that there was a critical size of sand involved in air entrapment. Sand over 14-mesh size was not effective; the air entrapment was on the finer sizes of sand. The air bubbles attached themselves to these small particles of sand and acted

like lubricants. This happened on particles up to 100-mesh size, but not on particles finer than 100-mesh. With the right sand mixture this effect of increasing workability and preventing segregation was so pronounced that a plain sand and coarse aggregate mixture, without any cement at all, would make a workable batch.

At a meeting of the National Ready-Mixed Concrete Association, Mr. Stanton Walker said that the State of Ohio would require the use of vinsol resin cements for concrete road slabs, and the Corps of Engineers was specifying those cements for certain projects. The strength of the concrete was known to decrease proportionately to the entrained air, and it was difficult to control the amount of entrained air. The air should be limited to 3 or 4 per cent., which would result in a decrease of 4½ to 6 lb. in the weight of a cubic foot of concrete. He mentioned a case where 11 per cent. of entrained air diminished the strength of the concrete by 50 per cent. Less fine aggregate in an amount equal to the volume of entrained air could be used in the mix apparently without detrimental effect.

Following Mr. Walker's introductory remarks, considerable discussion developed as to the amount of air entrained when tight drum mixers are used versus tilted open drum mixers.

Mr. F. N. Anderson said that the fines in the sand were the determining factor in air-entrainment. If the sand was high in fines it was difficult to finish the concrete. He had observed no difference in using the standard types of truck mixers. An engineer from the U.S. Corps of Engineers said that the type of mixer, in his experience, had no influence on the amount of air entrainment.

Mr. Wm. Elliott, of the Department of Public Works, New York City, said that it was impossible to control the blended Portland and natural cement concrete when mixed in ready-mixed concrete trucks of the horizontal drum type. Strengths varied as much as 1,000 lb. per square inch.

The Development of Air-entraining Cement.

As a result of heavy applications of salt and calcium chloride to concrete road surfaces to remove ice and frost, serious damage was often done in the form of scaling and disintegration, particularly in those cases where the concrete was less than four years old. Similar roads subject to extreme ranges of temperature and to frost and ice, but which have not been treated with salt or calcium chloride, showed no sign of deterioration. It was in an effort to obtain a concrete that would not be injured by applications of salt and calcium chloride that "air-entraining" cement was developed. It was found that a number of fatty and resinous materials, when ground with Portland cement clinker, gave the resulting cement the property, when mixed with aggregates and water, of forming in the concrete minute air bubbles, and that such concretes were more resistant to the action of frost and to the application of salts.

In the experimental work the materials tried included beef tallow, fish oil stearate, and a commercial product sold in the United States under the name of Vinsol resin; the last-named has been recognised as an air-entraining agent in the specifications of the American Society for Testing Materials and of the

U.S. Federal Government. This addition naturally reduces the specific gravity of the concrete and its strength, and it is stated that the best results are obtained when the quantity of the addition reduces the weight of concrete by between 3 lb. and 6 lb. per cubic foot. The loss of flexural strength with additions of Vinsol resin between these limits is from 10 per cent. to 15 per cent., and it is recommended that, if necessary, this should be restored by an increase in the cement content. The bulking effect of the entrained air increases the amount of mortar produced with a given quantity of cement, with a consequent increase in the workability of the concrete; this factor also permits some reduction in the quantity of sand in a concrete mixture, and of about ¼-gallon of water per cubic foot of cement. A mixing period of one minute is sufficient for the entrainment of sufficient air, while mixing for excessively long periods may entrain too much air with a consequent serious reduction in the strength of the concrete.

Mexican Specification for Portland Pozzolana Cement.

AFTER consultation with representatives of cement manufacturers and users, the Mexican Normas de la Secretaria de la Economia Nacional has prepared a specification covering three types of Portland pozzolana cements. The following are extracts from the specification, which was approved in October, 1943.

Definition.—Portland-pozzolana cement is a product obtained by grinding simultaneously Portland cement with natural or artificial pozzolanas. During the simultaneous grinding of these materials there is also permitted an addition of hydrated lime in amounts that do not exceed 10 per cent. of the total, and of other materials that do not exceed 1 per cent. of the total, nor have an injurious effect upon the ultimate quality of the cement. Pozzolana materials are those

TABLE I.

	Type.		
	A	B	C
Fineness, retained on No. 200 mesh, Maximum allowable, per cent.	13	13	13
Autoclave accelerated test :			
Maximum allowable expansion, per cent. ..	1·0	1·0	1·0
Maximum allowable contraction, per cent. ..	0·2	0·2	0·2
Expansion test at atmospheric pressure	Satisfactory	Satisfactory	Satisfactory
Initial setting time, Gilmore needle. Minimum in minutes..	90	90	60
Final setting time, Gilmore needle. Maximum in hours	10	10	10
Expansion in accelerated test of resistance to action of sulphates. Maximum allowable, per cent.	—	0·10	—
Compressive strength. Resistance of 5 cm. cubes of mortar 1 : 2·77 in kilos per square centimetre			
at 3 days, minimum strength	35	—	50
At 7 days, minimum strength	70	60	100
At 28 days, minimum strength	150	150	150

composed principally of acid or oxide silicas and calcium which in the presence of water at normal temperatures are capable of reacting with calcium hydroxide to form cementitious components.

Applications.—These cements may be used in concrete, reinforced concrete, as mortars and plasters of general character, in which a slowness of hardening and contraction upon ageing do not constitute a disadvantage. This refers to Portland-pozzolana cements Types A and B.

Characteristics and Classification.—Portland-pozzolana cements will be considered as being of three types: *Type A*, for general use; *Type B*, when a high resistance to the action of sulphates is desired; and *Type C*, when high initial strength is desired.

Specifications.—Portland-pozzolana cements must meet the chemical and physical specifications given in Tables I and II. No tensile tests are called for.

TABLE II.

	Type.		
	A	B	C
Silica oxide (SiO_2). Minimum allowable, per cent.	26·0	26·0	26·0
Sulphuric anhydride (SO_3). Maximum allowable, per cent.	2·5	2·5	2·5
Loss on ignition. Maximum allowable, per cent.	7·0	7·0	7·0
Calcium oxide (CaO). Maximum allowable, per cent.	58·0	58·0	58·0
Magnesia oxide (MgO). Maximum allowable, per cent.	4·0	4·0	4·0
Alkalis. Maximum allowable, per cent... ..	1·2	0·9	1·0

Sampling and Analysis of Coal and Coke.

A REVISED edition of British Standard No. 735, "Methods for Sampling and Analysis of Coal and Coke," has been issued by the British Standards Institution. Since the issue of this specification in 1937, two other specifications (Nos. 1016 and 1017) were issued in 1942 dealing with the same subject. These did not, however, supersede No. 735, which makes special provision for the greater accuracy required in plant performance tests. In the present revised edition of B.S. 735 advantage has been taken of the result of the investigations made in the preparation of the two 1942 specifications.

The specification covers the sampling and analysis of coal and coke, and contains three appendixes giving the dimensions of British standard sieves, a summary of experimental evidence on the collection of moisture sample, and descriptions of suitable forms of sample dividers; the last-mentioned appendix illustrates and describes the sample dividers used by Imperial Chemical Industries, Ltd., a cascade sample divider, a cone sample divider, and the rotating sample divider used by Messrs. Babcock and Wilcox, Ltd. Copies of the specification (price 5s.) are obtainable from the British Standards Institution, 28, Victoria Street, London, S.W.1.

Reaction Between Cement and Aggregates.

SOME notes on the expansion of concrete as a result of the reaction between Portland cement and certain types of aggregates were given in this journal for October, 1943. The results of further tests on this subject are now given by Mr. R. W. Carlson in a paper submitted to the American Concrete Institute and published in the "Journal" of the Institute for January, 1944. When Mr. T. E. Stanton disclosed in 1940 the large concrete expansions which occurred with certain reactive aggregates, the question was raised whether other aggregates were reactive also. The conditions under which expansion occurred were so exceptional that some reactive aggregates might exhibit no expansion in concrete and therefore be fully satisfactory for the conditions of use, while in a few cases imperfect performance might result without being attributed to the reactive aggregate. The large expansion seems to occur only (1) after months or years, (2) when the aggregate is reactive, (3) when a high-alkali cement is used, and (4) when the concrete is maintained neither fully wet nor dry. Only when all four of these conditions prevail is expansion likely to occur. As a result of later tests a fifth condition might be imposed for aggregates of lesser reactivity, namely, that the concrete expands only if it is kept warm as well.

In view of the slowness of the expansion due to alkali-aggregate reaction, and of the uncertainty about many siliceous aggregates, it appeared desirable to learn as soon as practicable which common minerals might cause expansion under conditions likely to be encountered, and whether reliance could be placed on results obtained under accelerating conditions. The principal accelerating conditions were believed to be (1) elevated temperature, (2) alkali added to the mix, (3) a rich mortar mix, and (4) aggregate size limited between about No. 48 and No. 4 sieves. Exploratory tests were begun in 1940 in the Massachusetts Institute of Technology laboratories on about 30 various aggregates. The more significant tests are reported here in Mr. Carlson's paper.

The aggregates were prepared to pass a No. 4 sieve and be retained on a No. 48 sieve, since it had been shown that the finer size caused less expansion. All aggregates were adjusted to a fineness modulus of 3·2 by adding the needed amount of limestone passing the No. 100 sieve; these fines were assumed to be non-reactive and later proved to be so. An arbitrary mix was used of 1 : 2 by weight (including the limestone fines as aggregate), and the water-cement ratio was 0·47 throughout. For the main tests two different mixes were employed, one of them containing a high-alkali cement and the other containing the high-alkali cement with 0·5 per cent. of Na_2O added as NaOH to the mixing water. Low-alkali cements were used as controls in a few cases only for very long-time tests. Three storage temperatures were adopted, namely, 70 deg. F., 110 deg. F., 150 deg. F. The specimens were small bars, 1½ in. by 1½ in. by 6 in., with stainless steel inserts at the ends for length measurement with a dial-type extensometer. The moisture was maintained in and around the specimens by placing each group of six bars on a grid shelf in an air-tight gallon can with a shallow layer of water in the bottom but not touching the shelf. All specimens

were left in the moulds for one day at about 75 deg. F.; initial readings were then taken and specimens placed in metal cans for continued storage at the respective temperatures.

A number of practically pure minerals was included among the aggregates. The particular dilution of an aggregate producing greatest expansion appeared to have been missed for several of the most reactive aggregates, particularly siliceous magnesian limestone, and possibly for Muscovite mica. The siliceous magnesian limestone was used at 5 per cent. only, the remainder being siliceous sand shown later by separate tests to be slightly reactive at elevated temperatures. It has been shown that 20 per cent. of this material is the worst amount. The Muscovite mica also was used at 5 per cent. only, it also being diluted with siliceous sand. There is little evidence as yet regarding the worst percentage of the mica.

The mortar expansions observed with most of the aggregates are shown in Figs. 1, 2, and 3. In all cases, the broken lines refer to specimens containing 0·5 per cent. of added sodium oxide (as NaOH). The solid lines refer to specimens containing the same cement which had more than 1 per cent. of the combined oxides of sodium and potassium, but with no alkalis added to the mixing water. All normal-weight aggregates containing silica caused some mortar expansion, although in many cases the expansion was little or none at 70 deg. F. up to more than two years. On the other hand, aggregates containing no silica caused no expansion. Greatest expansion was caused by 5 per cent. of shale blended with 95 per cent. of sand. This expansion was 2 per cent. of the length, or about 6 per cent. of the volume, of the mortar, and the maximum expansion occurred at 70 deg. F. The shale contained what is called " opaline " silica, as did the siliceous magnesian limestone. It is probable that equally large expansions would have been observed with these materials had the worst percentage been used.

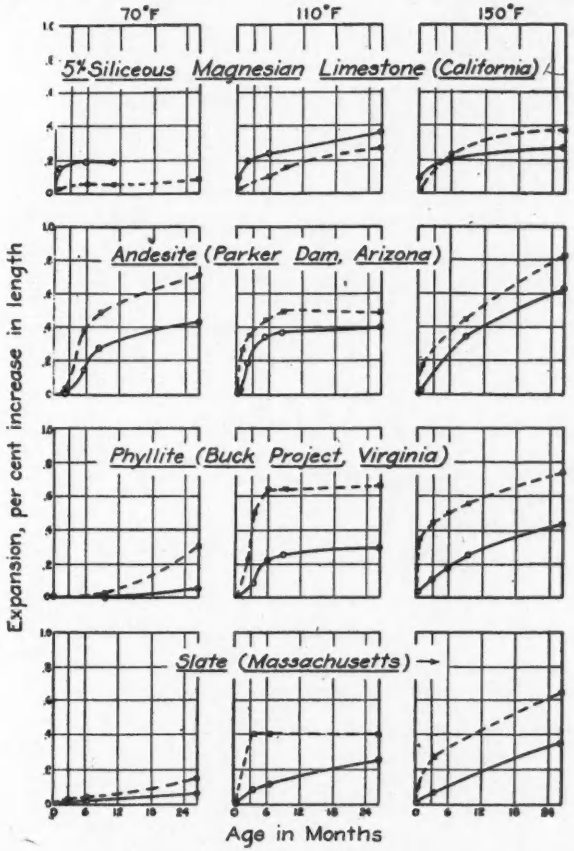
Although the elevated temperature appears merely to hasten the expansion of the mortar, it remains to be proved whether some siliceous materials like quartz and graywacke will ever cause expansion at 70 deg. F. If such materials did cause expansion under long-continued moist storage at 70 deg. F., they would only be expected to cause expansion in structures at that temperature where the other conditions are such as to preserve both the alkalis and the needed degree of moisture continually within the concrete. Observations are being continued on the specimens which showed expansions at elevated temperatures but little or no expansion at 70 deg. F.

The effect of adding sodium hydroxide to the mixing water is generally to produce quicker and larger expansions, but the effect is not fully consistent. For example, the added alkali reduced the expansion where siliceous magnesian limestone was the aggregate, while in the case of quartz the added alkali caused a surprisingly large expansion at 150 deg. F. only. In the latter case, however, by an accident, the moisture was lost from the can holding the quartz specimens at 150 deg. F.; after restoring the moisture in the can at the age of ten months without wetting the specimens, the specimens containing added alkali began to grow disproportionately. This seems to indicate that there may be a certain

intermediate moisture condition (probably governing the concentration of alkalis in solution) which is much worse than the arbitrary moisture content due to retaining the original mixing water.

Spots appeared on all specimens showing even moderate expansion, but not on specimens which did not expand. The spots differed widely in shade, some being nearly white and others being nearly black.

Perhaps the most consistent behaviour was shown by specimens containing the artificial aggregate known as "fused kaolin"; the mortar expansion was increased consistently with higher temperature and with added alkali. The times required to reach an expansion of 0·1 per cent. without added alkali were

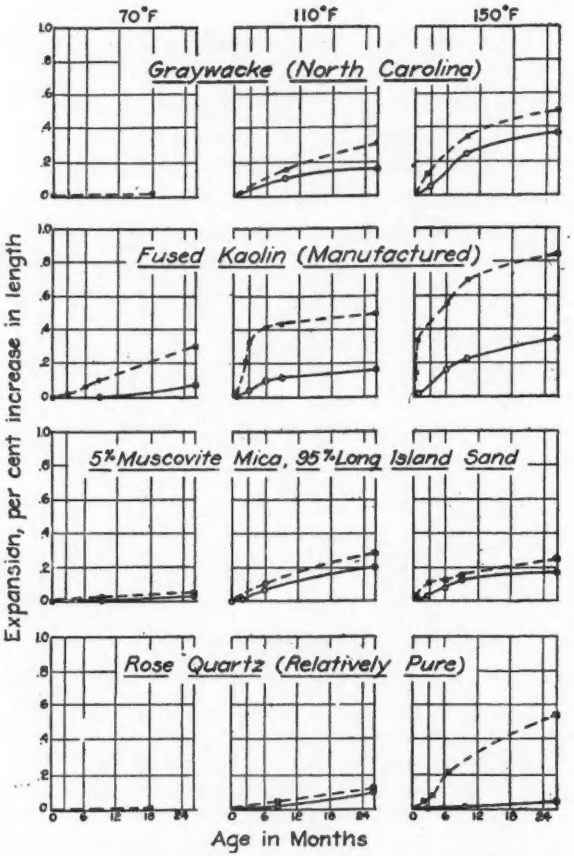


Solid lines refer to mortars made with high-alkali cement. Dash lines refer to mortars containing high-alkali cement with the addition of 0·5 per cent. Na_2O by weight.

Fig. 1.—Expansion of Mortars containing Andesite, Phyllite, Siliceous Magnesian Limestone, and Slate.

respectively about three months, six months, and more than two years for temperatures of 150, 110, and 70 deg. F. With added alkali the corresponding times were two weeks, six weeks, and 32 weeks. With the fused kaolin the effect of added alkali was unusually large.

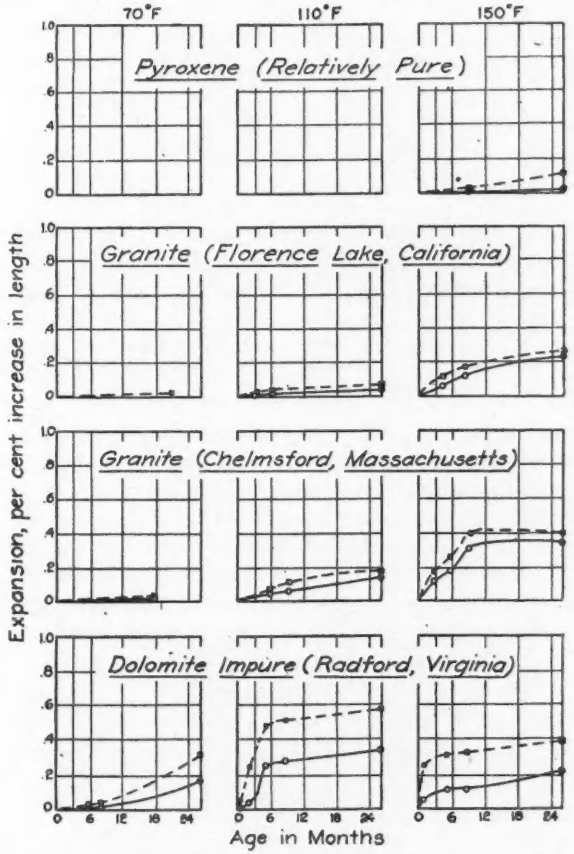
Low-alkali cements produced little or no expansion at any temperature with mildly reactive aggregates up to two years. The impure dolomite, for example, was tested with five other cements besides those for which results are shown in Fig. 3. These other cements had total alkali contents ($Na_2O + K_2O$) of 0·36 0·46, 0·62, 0·75, and 1·15 per cent. Only the two highest alkali contents produced appreciable expansion in the two years of observations, even at elevated



Solid lines refer to mortars made with high-alkali cement. Dash lines refer to mortars made with high-alkali cement with the addition of 0·5 per cent. of Na_2O by weight.

Fig. 2.—Expansion of Mortars containing Fused Kaolin, Graywacke, Muscovite Mica, and Quartz.

temperatures. If the combined accelerating effects of the elevated temperature, the mortar mix, and the selected sizes amount to as much as ten times normal rate, then the low-alkali cements would be proof against alkali-aggregate expansion for at least 20 years. For the purpose of preventing serious expansion where mildly reactive aggregates must be used, the restriction of the amount of the oxides of sodium and potassium in the cement seems to be desirable. This conclusion must remain tentative until such time as continued tests provide a sound basis for an ultimate decision as to the best corrective measures. The significance of the accelerated tests on mildly reactive aggregates should become more clear when, in addition to continued tests, a number of corresponding structures have been observed over long periods.



Solid lines refer to mortars made with high-alkali cement. Dash lines refer to mortars made with high-alkali cement with the addition of 0·5 per cent. Na_2O by weight of cement.

Fig. 3.—Expansion of Mortars containing Pyroxene, Granite and Dolomite.

The Efficiency of Lime Kilns.

THE possibilities of increasing the efficiency of lime kilns is dealt with by Mr. V. J. Azbe in a recent number of " Rock Products." A kiln direct-fired with powdered coal is taken by the author in order to show the degree of inefficiency that is possible.

The inefficient rotary kiln has no lime cooler, or it has a cooler wasting recovered heat. The terminal temperature of escaping gases is 1,500 deg. F., and combustion would be complete within the kiln and not extend into the settling chamber. If combustion is complete the stack loss is further augmented by a certain amount of excess air. The heat energy is of high as well as of low intensity. The dissociation temperature of limestone is the dividing point : this varies with CO_2 concentration adjacent to and permeating the lime layer on the stone. On the average, with small stone in a rotary kiln, it will be less than with large stone in a vertical kiln. To assume a temperature of 1,500 deg. F. should be fairly safe.

If escaping-gas temperature from a kiln is 1,500 deg. F., and the dissociation point is 1,500 deg. F., then all the heat in preheating the stone came from the high intensity portion, meaning that none of the heat of low intensity was, or could be, utilised. Also the source of heat radiated from the shell throughout its length was from the high intensity portion. There would be no recuperation and no regeneration ; all the sensible heat in the lime would go to waste ; all heat below 1,500 deg. F. in the gases would go to waste ; excess air would further waste heat from the high intensity stream and from radiation in a rather considerable amount. Some kilns operate precisely like this, and many are very close to it. To prove this their fuel—lime ratio need only be compared with that developed here.

The fuel is a good high-grade 14,000 B.T.U. coal, but percentages here given would apply to coal of any heat value and, roughly, also to oil. Heat in coal can be divided into three portions : " Unavailable "—which represents latent heat of water vapour ; " High intensity "—about 1,500 deg. F. ; and " Low intensity "—1,500 deg. F.

HEAT DISTRIBUTION FROM ONE POUND OF COAL

14,000 B.T.U. = 100%

	B.T.U.	Per cent.
" Unavailable " due to latent heat of H_2O	730	5.14
" Low intensity " below calcination temperature ..	4,580	32.74
" High intensity " above calcination temperature ..	8,690	62.12
	14,000	100.00

In any kiln the 5.14 per cent. portion would be lost ; in a kiln such as we are now contemplating the 32.74 per cent. would also go to waste, and in addition, the following amount of the 62.12 per cent. portion.

Total available, 8,690 B.T.U. = 62.12 per cent.

	B.T.U.	Per cent.
Excess air loss (20 per cent. excess air)	847	6.03
Radiation loss (15 per cent. of total heat)	2,100	15.00
Total of high intensity heat loss	2,947	21.03
Total of high intensity heat remaining	5,743	41.09

Next we determine the amount of heat necessary to preheat and calcine one pound of lime. Under these conditions all such heat will be derived from the "high intensity" portion and, dividing the heat available (5,743 B.T.U.) by the heat required per pound gives the attainable fuel ratio.

HEAT NECESSARY FOR CALCINATION AND PREHEATING FOR ONE POUND OF LIME

	B.T.U.
Preheating of CO_2 portion of limestone to 1,500 deg. F.	390
Preheating of CaO portion of limestone to 2,400 deg. F.	620
Heat of calcination reaction to CaO at 1,500 deg. F. ..	1,220
Total heat of preheating and calcination	2,230

Lime-fuel ratio $\frac{5,743 \text{ B.T.U.}}{2,230 \text{ B.T.U.}} = 2.57$ to 1.

This 2.57—1, or 72 gallons of oil per ton of lime, may be considered the lowest in performance and many kilns come very close to it, as a ratio of 3—1, or an oil consumption of 63 gallons is common. This ratio is 3 to 1 rather than 2.57 to 1 because lime is not 100 per cent. CaO, so actually less heat is necessary than was assumed; also because some of the heat in the lime may be recovered in the last few feet of the kiln and some of the "low elevation" heat utilised for stone preheating, as also radiated from the kiln shell, in place of the heat of "high elevation."

Now that the low standard has been established, it would be of interest to develop the high standard. We will assume the same heat division between the high and low intensity portions, also the same loss due to water vapour, excess air and radiation. We will merely manipulate heat requirements for lime making in accordance with the prevailing conditions: full cooling of lime for one, and full cooling of lime plus full preheating of stone with low intensity heat for the other. Assuming that the kiln gas temperature would still be 1,500 deg. F., but that the kiln was equipped with an efficient lime cooler fully recovering sensible heat of the lime and returning all of it to the kiln, the heat necessary for calcination and preheating per pound of lime would be:

	B.T.U.
Calcination reaction at 1,500 deg. F.	1,220
Preheating of CaO portion of lime (all returned by cooler)	—
Preheating of CO_2 portion of limestone	390
Total heat abstracted from high elevation heat stream	1,610

As all sensible heat of lime is returned to the kiln, none can be charged for, but as all of it came from the high intensity portion there is no credit. Fuel ratio is increased, but not in the measure possible when stone is preheated with waste heat. Supposing that this is the case, all stone preheating is done with heat of low elevation and all sensible heat in the lime is recovered and returned to the kiln. The total high heat requirement per pound of lime would then be :—

	B.T.U.
Calcination reaction at 1,500 deg. F.	1,220
Preheating of CO_2 portion of limestone (recuperative) ..	—
Preheating of CaO portion of limestone (credit)	390
Total heat of high elevation	830

The most interesting thing here is that by preheating followed by cooling we recover low intensity heat and recuperate it in the cooler to high intensity and thus accomplish a remarkable saving.

Summarising the three conditions, we obtain :

	B.T.U. per lb. of lime	Fuel ratio
(A) High heat stone preheating, no lime cooling ..	2,230	2.57
(B) High heat stone preheating, fully effective cooling	1,610	3.57
(C) Low heat stone preheating, fully effective cooling	830	6.92

The high standard has a ratio of practically 7 to 1, but is approachable only when the kiln is augmented by an effective cooler and stone preheater, for example, as illustrated in Fig. 1. The main features of this plan of rotary kiln operation are :—

(1) A direct contact lime cooler, as only through intimate contact of lime and air can lime be effectively cooled. The cooler incorporates special arrangements for air distribution and dust interception.

(2) A direct contact stone preheater with gas intake and offtake, very similar to that used for many years in stone preheating sections of vertical kilns.

(3) A twin system of powdered fuel injection, one arranged for dispersion of fuel stream and short flame, the other intended for projection and long flame.

(4) High strength CO_2 recirculation for tempering of flame with a source point equal to the vertical kilns.

(5) Induced draught operation attained with preheater fan.

(6) A heavy outlet construction to increase kiln load, time of lime in the kiln and upper heat absorbing surface.

(7) A stone screw to permit heavy feeding with no back-spilling.

When efficiency is high temperature is high and, as there are refractory limitations, the double system of burning is incorporated. Of the two fuel injectors,

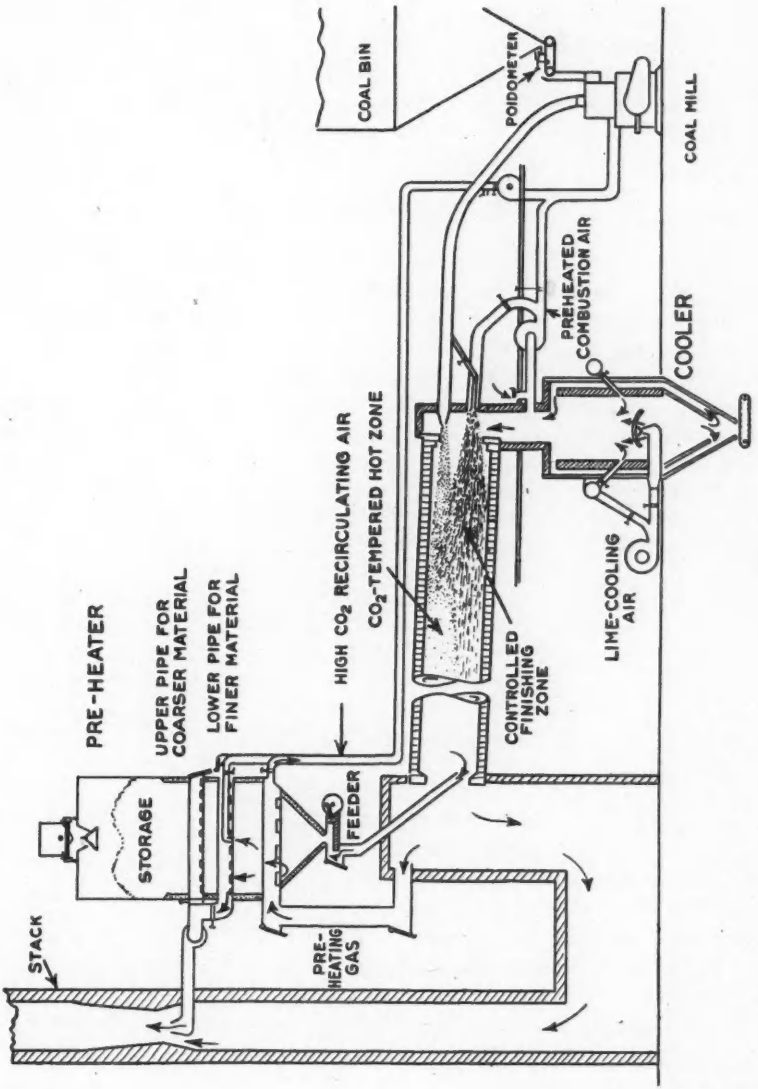

COAL BIN
POIDOMETER
COAL MILL
PREHEATED COMBUSTION AIR
COOLER
HIGH CO_2 RECIRCULATING AIR
CO_2-TEMPERED HOT ZONE
CONTROLLED FINISHING ZONE
LIME-COOLING AIR
PRE-HEATER
UPPER PIPE FOR COARSER MATERIAL
LOWER PIPE FOR FINER MATERIAL
STORAGE
FEEDER
STACK
PRE-HEATING GAS

Fig. 1.

the one for far projection carries most of the fuel, while the second is used to regulate the quality of the outpouring lime in relation to its calcination. Such a double system will lengthen the ordinarily very short hot zone and reduce its peak temperature, and thus reduce the tendency to scale and ring formation. Additional heat control can be obtained by injecting CO_2 high gases.

The arrangement calls for only part of the kiln gases passing through the stone preheater; such part as is necessary to preheat the stone to 1,500 deg. F. They may pass out at either of the two levels, this depending on size of stone, or the stream may come out divided to both.

Saw for Cutting Concrete Specimens.

A small diamond saw for the preparation of thin sections of rock and concrete for petrographic studies is in use by the California Highways and Public Works Department. The machine may also be used to saw thick sections of concrete. The sawing element consists of a 20-in. diameter diamond-studded steel disc mounted on a ball-bearing spindle, with a pulley on the other end driven by a belt from a $\frac{1}{3}$-h.p. electric motor. The speed of the cutting edge is 2,200-ft. per minute. It dips into a mixture of oil and kerosene.

In making the saw, its edge was first rolled to a width of $\frac{1}{10}$-in. and to a depth of $\frac{3}{64}$-in., after which each $\frac{1}{4}$-in. of the circumference was cross-cut to a width of 0·028-in. and a depth of $\frac{1}{32}$-in. Next fine diamond chips were placed in the cross-cut slots, which were then lightly peened. The disc was re-rolled to force the metal firmly around the diamonds, but still maintaining the $\frac{1}{10}$-in. width. The saw was then mounted on the arbor of the machine and, with a medium-grade carborundum block in the specimen holder, the machine was operated with a light pressure to wear off the surplus metal, thereby exposing the diamonds in the cutting edge and making the saw ready for use.

Slices as thin as $\frac{1}{32}$-in. may be prepared, and it is stated that cuts on all materials may be smooth enough to polish without preliminary lapping.

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ROTARY DRYER (Humidity Type) by Wm. Gardner. 30 ft. by 3 ft. dia. Type W.1, 60-in. fan, Pulley, no water-jacketing bearings. Furnace lined with firebricks, Type W.1 chimney, 8 h.p. A.C. motor, 400 volts, 50 cycles, starter and gear. Weight 8 tons. Graham & Co., Ltd., 15, George Street, E.C.4.

Properties of Masonry Cements.

SOME results have been published of tests on masonry cements started in 1938 at the University of Wisconsin, and are given in more detail in the Journal of the American Concrete Institute for November, 1943. The tests were confined to workability, durability, and strength.

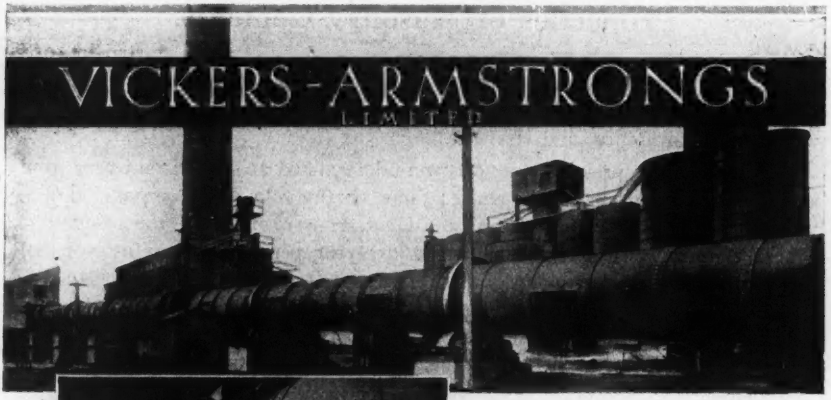
Tensile and compressive strengths were determined at six different ages from seven days to five years on 1 : 2 and 1 : 3 mortars (by volume). Compression tests were made on 390 2-in. cubes, and tension tests were made on 360 briquettes. Linear changes were determined over a five-year period on 1 : 3 (by volume) prisms cured in a moist closet, under water, and in outdoor air. Autoclave expansions were also determined ; for this programme 54 prisms were made, 1-in. × 1-in. × 6-in., with brass lugs inserted in the ends. Repellency tests were made on 36 2-in. cubes, and water retention tests were made on 1 : 2 and 1 : 3 mortars (by volume).

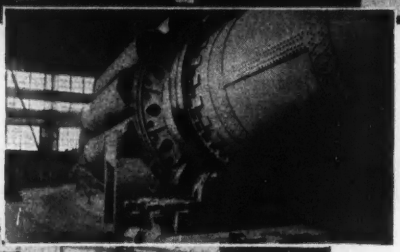
The masonry cements used were all purchased on the open market. The sand used was a mixture of quartz and dolomite particles with a fineness modulus of 2·08. While the two mixes used were chosen on a 1 : 2 and 1 : 3 volume basis, the actual proportioning was done by weight. In order to convert from volume proportions to weight proportions, the specific weights of the materials in lb. per cubic foot were taken as follows : Sand, 85 ; Brixment, Aetna, Petoskey, and Carney masonry cements, 65 ; Dewey and Utica cements, 67 ; Lehigh cement, 70. Generally, the test procedures followed those recommended in Federal Specification SS-C-181b. The tensile and compressive specimens were made from mortars with a flow of 65 to 80 per cent., and were moist cured for 28 days (during the first 48 hours in the moulds). At 28 days half of the specimens were placed outdoors and the remaining half were kept in the moist closet until tested. In the water retention test the flow after suction was determined after allowing the mortar to age for 15 minutes and then remixing for one minute.

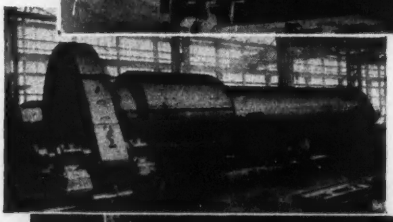
For the autoclave tests the prisms were aged about 53 hours, surface dried, and measured to the nearest 0·0001 in. in a comparator. They were then placed on a rack in the autoclave and subjected to saturated steam at a pressure of 150 lb. per square inch within one hour. After this pressure had been maintained for three hours it was gradually released within a period of five minutes. The prisms were then removed and immersed in water at 150 deg. F. and cooled to room temperature in a period not less than 30 minutes. The prisms were then surface dried and remeasured.

The results of the tests show that all the cements easily passed the specification requirement that the ratio 1-hour absorption to 24-hour absorption be less than 90 per cent. The data also show that generally the 1 : 3 cubes had greater absorptions than had the comparable 1 : 2 cubes.

The ratios of flow after suction to initial flow for the 1 : 2 mixes are higher than those for the comparable 1 : 3 mixes. All of the masonry cements except Utica showed satisfactory performance in this test. To produce mixes of similar







Cement Making Machinery

PATENT SLURRY DESICCATORS.

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consistency (initial flow from 100 to 115 per cent.) there was a decided spread in the required water-cement ratio which ranged from 0·46 to 0·59 for the 1 : 2 mixes, and between 0·58 and 0·73 for the 1 : 3 mixes.

During the five-year period the compressive strength of the 1 : 2 and 1 : 3 mortars generally showed a continued increase for both methods of curing, while the tensile strength usually showed very little change after 90 days. For a given condition the specimens cured in outdoor air generally had better tensile and compressive strengths than did those cured in the moist closet, although the specimens made with Utica masonry cement did not appear to follow this general behaviour. Under similar conditions the 1 : 2 mortars had higher compressive strengths than the 1 : 3 mortars and also usually had higher tensile strengths.

Mortar prisms, 1 : 3 by volume, were subjected to the autoclave test previously described and the following expansions in millionths of an inch per inch were obtained : Dewey, 650 ; Lehigh, 683 ; Aetna, 900 ; Petoskey, 925 ; Utica, 1,300 ; Carney, 25,500 ; Brixment, disintegrated. The high expansions obtained with the Carney and Brixment mortars were probably due to the action of unhydrated material.

During a five-year period under moist storage all specimens showed some expansion, but only Brixment and Carney cements showed a continuous gain in expansion with time ; Carney cement had an expansion of 0·001 in. per inch. Under water storage, Brixment cement again exhibited a continuous gain in expansion with time ; Carney cement was not tested in this programme. Under outdoor air storage, all cements showed an increase in contraction with time up to about 90 days, while changes beyond that time were usually not very great. At five years the contractions varied between 500 and 1,000 millionths of an inch per inch. Utica, Brixment, and Petoskey cements had the highest contractions.

Conclusions.

(1) The six masonry cements tested exhibited satisfactory water repellency properties.

(2) All the cements tested, except Utica, had satisfactory water retention properties, the best being Aetna cement.

(3) For both conditions of storage, moist closet and outdoor air, the compressive strengths of the 1 : 2 and 1 : 3 mortars generally increased with age. The tensile strengths of the same mortars increased with age up to approximately 90 days, after which changes were usually small.

(4) Except for Utica cement, the strengths of the specimens cured outdoors were generally higher than those cured in the moist closet.

(5) Mortars made with Carney and Brixment cements showed very high expansions in the autoclave test.

(6) Under moist air storage conditions all specimens except those made with Brixment and Carney cements showed very little length change. For the two exceptions the lengths increased with the time. Brixment cement behaved

in a similar manner under water storage, while Carney cement was not tested under this condition.

(7) Under dry air storage conditions all specimens contracted in length, but after 90 days the changes were usually small.

(8) For the tests conducted, Aetna, Dewey, Lehigh, and Petoskey cements showed satisfactory performance.

The Properties of Pozzolanas.

IN the report for the year 1942 of the non-metals division of the United States Bureau of Mines, Messrs. O. C. Ralston and A. G. Stern give some notes on their investigations (which are continuing) on the chemical and physical properties of pozzolanic materials such as volcanic ash, diatomite, burnt clay or shale, etc., used in Portland cement concrete. It is stated that the alumina in these minerals may unite with lime to form hydrated calcium aluminates. The experimental procedure consists mainly in preparing calcium aluminates by precipitation and rotating these in a water bath at 30 deg. C. to equilibrium in contact with lime-water solutions. X-ray diffraction patterns were taken of the residues, and their refractive index was determined.

A dicalcium aluminate, $2CaO.Al_2O_3.8H_2O$, was found dissolving without decomposing in water to give the following concentration: 8·02 millimoles CaO/1 and 4·00 millimoles Al_2O_3/l. A tricalcium aluminate, $3CaO.Al_2O_3$, with about $12H_2O$, was also found, giving a characteristically different X-ray pattern. It dissolves without decomposition in water. Both the di- and tri-calcium aluminate formed solid solution with $Ca(OH)_2$, the former to a ratio of $CaO:Al_2O_3$ of 2·2 and the latter to about 3·5. The di- and tri-calcium aluminate solid solutions exist in isothermal reversible equilibrium in contact with the following solution: 10·9 plus or minus 0·7 millimoles CaO/l and 1·20 plus or minus 0.2 millimoles Al_2O_3/l. There was evidence, also, of a Beta-tricalcium aluminate with characteristic higher ratios of $CaO:Al_2O_3$ approaching 4. These results were supplemented by observations on complex carbonates and silicates of calcium aluminate.

The tricalcium aluminate solid solution reverted readily to the stable isometric $3CaO.Al_2O_3.6H_2O$. However, dicalcium aluminate was apparently stable, except in contact with lime-water solutions above the invariant concentration. Several difficulties were experienced in attempting to establish the solubility curve for the isometric compound. A series of solubilities was finally obtained for lime-water concentrations from nil to saturation.

The plasticising action of pozzolanic minerals is generally recognised. Comparative measurements were made for a series of pozzolanic materials added to mortar. Plasticity was measured upon the basis of stress-strain relationship, leading to determination of a coefficient of plasticity, and a yield value analogous to that for metals. Workability is a more complex property than plasticity

and consists of at least four factors. Plasticity is one of these and concerns ease of deformation. The other factors are water retention, stability of the thick suspension as regards rupture, and adaptability of the suspension to extensive deformation. Particularly noteworthy was the plasticising action of bentonite, ball clay, and powdered diatomite. The coefficient of plasticity was a good measure of overall workability and correlated well with the directly measured water retention. The latter appeared to be relatively low for masonry mortars as against those with mineral powder additions.

Fuel Economy.

A NUMBER of bulletins on economy in solid and liquid fuel has been issued by the Ministry of Fuel and Power, and may be obtained free of charge from the London or Regional offices of the Ministry. The bulletins include the following :—

" Steam Production and Consumption."—Boilerhouse measurements ; sources of steam loss ; traps and condensate ; water treatment ; superheaters ; economisers ; boiler operation and maintenance.

" How to Make a Simple Steam Meter for use in Factories."—Steam flow meters of the orifice type ; numerical example, tables, graphs, and working drawings.

" Control of Excess Air on Steam Raising and Central Heating Plants."—Combustion and air supply ; figures and chart for flue loss ; drawings of draught gauge and of dampers on shell-type boilers and hot-water boilers.

" Superheated Steam."—Factors which determine whether steam should be superheated ; theory of superheat ; sketches of gas path, and effect of deflector.

" Cooling Fire-bars in Industrial Furnaces and Boilers."—Waste occurring when the principles of fire-bar cooling by steam are abused ; the possibility of using finely atomised water sprays.

" The Control of Air for Combustion."—Air infiltration ; tests for leakage ; methods of sealing ; damper control.

" Correct Methods of Condensate and Air Removal."—Types and relative merits of different steam traps ; installation, operation, and maintenance.

" How to make the Best Use of Condensate."—Heat in condensate ; possible uses ; methods of return ; flash steam.

" The Sensible Use of Latent Heat."—Power production ; process and space heating arranged in series instead of parallel ; details of the application of latent heat using the multiple effect evaporator.

" Utilisation of Steam."—Including transmission ; space heating and process ; latent heat, heat transfer, traps, flash, and condensate.

" Peak Steam Demands. Cause, Effect, and Cure."—Effect on output and efficiency, smoothing out peaks, steam accumulators, load rationalising.

" Flash Steam and Vapour Recovery."—Use of flash ; size of flash tank ; pumping hot condensate ; flash cooling ; practical application.

" Heat Insulation (Lagging)."—Materials and methods of lagging steam and hot water pipes, boilers, calorifiers, cylinders, and steam chests.

"Thermostatic Control for Hot Water and Steam."—Thermostatic control of central heating; hot water supply; process heating; internal combustion engines and boilers; apparatus and maintenance.

"Insulation of Furnaces."—Value of insulation in reducing heat losses through furnace brickwork and through the storage of unnecessary heat; effect of continuous and intermittent operation.

"Fuel Economy by Saving Electricity."—Lighting; power; heating and general economies; speed reduction.

"Heavy Oil Engines."—Collection of cleaning oil; drainage and leakages; avoidance of spillage; jacket water; pump settings; maintenance; loading; lubricating oil; log sheets, rota for cleaning and overhauls.

"The Industrial Use of Liquid Fuel."—Responsibility; records; spillage and leakage; care of burners; furnace operation; loading; brickwork; insulation; waste heat recovery.

"The Effect of Variations in Output on Heat Consumption."—Methods of plotting and assessing input in relation to output; detailed example.

"The Construction of a Factory Heat Balance."—Methods for the preparation of an approximate heat balance without elaborate instruments.

"Steam for Process and Heating."—Introduction to the steam tables; sensible heat; latent heat; saturated and superheated steam; accumulators; flash; wiredrawing; de-superheating; steam quality.

United States Cement Production.

THE United States Bureau of Mines states that 133,483,000 barrels of cement were produced in the United States in the year 1943, and 127,567,000 barrels were delivered. These figures are respectively 27 per cent. and 31 per cent.b elow the quantities produced and delivered in the previous year. The decline was progressive throughout the year; for example, in December, 1943, the production and deliveries were 41 per cent. and 37 per cent. respectively below the corresponding figures for December, 1942. The ratio of production to capacity was 54 per cent. for the year 1943 compared with 74 per cent. in 1942. For the month of December the ratio of output to capacity was 40 per cent. in 1943 compared with 67 per cent. in 1942.

Planning a Cement Works.

A BROCHURE entitled "Choosing a Cement Plant" has been issued by Messrs. Edgar Allen & Co., Ltd., of Imperial Steel Works, Sheffield. This has been produced for the guidance of those contemplating the erection of a new cement factory, and describes the various manufacturing processes and the plant recommended by the Company. The brochure, of 24 pages, is illustrated with photographs of the firm's plant, and includes a recommended flow-sheet. Comments are given on the reasons which underlie the selection of particular types of plant in different circumstances.